Implementing a Rural Groundwater Management System

A step-by-step guide

the dwaf
DEPARTMENT OF WATER AFFAIRS AND FORESTRY
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NORWEGIAN AGENCY FOR DEVELOPMENT COOPERATION

TOOLKIT for WATER SERVICES: Number 1.2

The purpose of this document is to provide guidelines to follow in establishing a groundwater management system at a municipality. The target audience is Catchment Management Agencies and Department of Water Affairs and Forestry regional structures supporting Water Services Authorities.

Implementing a Rural Groundwater Management System : a step-by-step guide

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Foreword

Toolkit for Water Services

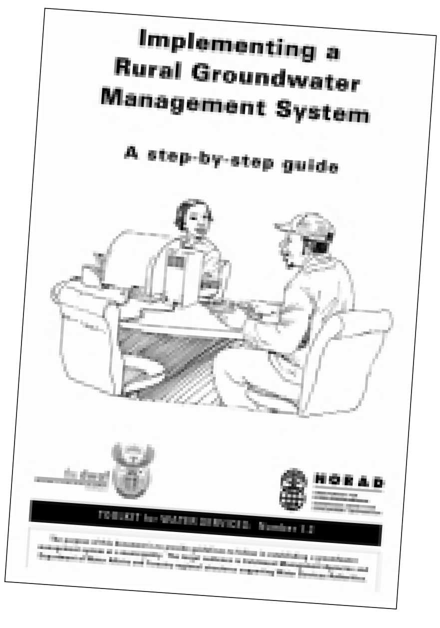
Groundwater has historically been given limited attention, and has not been perceived as an important water resource, in South Africa. This is reflected in general statistics showing that only 13 % of the nation's total water supply originate from groundwater. However, because of the highly distributed nature of the water demand in rural and informal peri-urban settlements, regional schemes are, in most instances, not economically feasible. And because of generally increasing water scarcity and decreasing available river and spring flows during low flow and drought periods, as well as wide-spread problems of surface water pollution in rural areas, groundwater will be the most feasible option for a large part of the new water demand. Already it is estimated that over sixty percent of community water supply is from groundwater, making it a strategically important resource.

The NORAD-Assisted Programme for the Sustainable Development of Groundwater Sources under the Community Water and Sanitation Programme in South Africa was managed by the Department of Water Affairs and Forestry (DWAF) between 2000 and 2004. The Programme undertook a series of inter-related projects aimed at enhancing capacity of water services authorities and DWAF to promote and implement sustainable rural water supply schemes based on groundwater resources and appropriate technologies.

Page 2 has a full list of the Programme outputs. The formats for these range from documents to software programmes and an internet portal, to reference sites where communities have implemented appropriate technologies. For more information on the "package" of Programme outputs contact your nearest DWAF Regional Office or Head Office in Pretoria.

It is our sincere hope that this Programme will contribute to the body of work that exists to enable more appropriate use and management of groundwater in South Africa.

Implementing a Rural Groundwater Management System - A step-by-step guide is Number 1.2 in the Toolkit for Water Services. The purpose of this document is to provide guidelines to follow in establishing a groundwater management system at a municipality. The target audience is Catchment Management Agencies and Department of Water Affairs and Forestry regional structures supporting Water Services Authorities.



Toolkit for Water Services

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Acronyms

CMA	Catchment Management Agency
CWSS	Community Water Supply and Sanitation
DWAF	Department of Water Affairs and Forestry
EC	Electrical Conductivity
O&M	Operation and Maintenance
SSA	Support Services Agent
WRM	Water Resource Management
WSA	Water Services Authority
WSDP	Water Services Development Plan
WSP	Water Services Provider

1 Introduction

Context

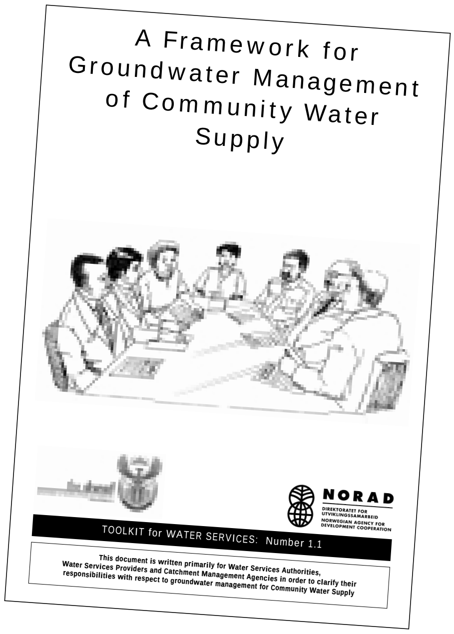
This step-by-step guide has been written for Department of Water Affairs and Forestry (DWAF) regional staff, and the staff of future Catchment Management Agencies (CMAs), who will be tasked with establishing groundwater management systems for municipal production boreholes. The guide is based upon the following key assumptions:

- That all the required procedures, in relation to setting up a groundwater management system, have been followed within DWAF.
- That the decision to proceed with setting up a groundwater management system has been taken at the appropriate forum/s.
- That groundwater management has been identified as a priority at the cluster and regional levels of DWAF.
- That planned interventions have been discussed at regional planning forums.
- That prior to engaging with municipalities, all of the appropriate directorates have knowledge of, and support the planned intervention/s.

Purpose of this document

The purpose of this document is to provide guidelines to follow in establishing a groundwater management system at a municipality. The target audience is primarily CMAs and DWAF regional structures involved in managing water resources and supporting Water Services Authorities (WSAs).

It should be read in conjunction with the document entitled, ***A Framework for Groundwater Management of Community Water Supply*** (Toolkit for Water Services number 1.1), which covers:



- DWAF's vision for rural groundwater monitoring and management.
- The need for rural groundwater management.
- Institutions' legal responsibilities relating to groundwater management in rural community water supply.
- A proposed groundwater management system.
- The tasks required for groundwater management.

Guiding principles for rural groundwater management

- **Integration with operation and maintenance (O&M) activities.**
  Monitoring activities at both project and management level need to be integrated with the O&M activities of the WSA or Water Services Provider (WSP). At the project level, monitoring and recording of water levels and abstraction should be part of the ongoing activities of the pump operator.

- **Groundwater monitoring should be part of a monitoring system that includes all aspects of a scheme's operation.**
  In order to promote a sustainable scheme, groundwater, together with all other key activities, needs to be monitored. These activities include amongst others, the servicing of diesel engines, determining the water balance and water losses, cleaning reservoirs, establishing tap water quality and general network maintenance activities.

- **Only process data that is necessary for groundwater management.**
  Logbooks should be kept for all boreholes, but detailed analyses of the data should only be necessary for selected boreholes, where there is a potential for over-abstraction or for water quality problems.

- **Integrate with other water resource management (WRM) institutions.**
  The CMAs need to know what data is available from monitoring at the local level, and they need to be able to access this data, if and when needed. It is, however, important not to overload CMAs with data that they do not need and cannot process. Only summary data should be provided to the CMA.
  This would typically contain:
  - The data available for each borehole.
  - Annual total abstraction and daily average per borehole.
  - Maximum and minimum water levels recorded, and the dates recorded per borehole.
  - Borehole water quality changes.

Groundwater users

Groundwater users fall into three categories, namely: unregistered users, users requiring registration and licensed users. The different categories of users are defined below and summarised in **Table 1** on page 7.

- **Unregistered users**
  Unregistered users are those users who are extracting a minimal quantity of groundwater on any given day per property. In terms of the National Water Act (1998), they are not required to register this use. Presently, this makes reference to users who use less than 10 kilolitres of groundwater on any given day. In terms of rural water supply, this would typically cover individuals who have a borehole, and who use the water for personal domestic and garden irrigation use.

The following water use detailed in Schedule 1 of the National Water Act (1998) need **not** be registered:

Taking water directly from any water resource to which a person has lawful access, for:

- reasonable domestic use in a person's household;
- small gardening (but not for commercial purposes); and
- the watering of animals (but not for commercial purposes, thus excluding feedlots), provided that the use is not excessive in relation to the capacity of the water resource and the needs of other users.

- **Registered users**
  In terms of the National Water Act (1998), all users that abstract more than 10 kilolitres per property on any given day are required to register this water use. Typically, this would require a municipality to register all boreholes within its jurisdiction.

- **Licensed users**
  A water user is required to apply for a license when the water use exceeds the limits specified in the general authorisations contained in Government Gazette no. 20526 of 8 October 1999, which is updated regularly.

Table 1: Categories of groundwater users

Type of user	Limits	Typically	Monitoring requirements
Unregistered	Schedule 1 use, or less than 10 kilolitres per property on any given day.	Private borehole used for domestic and domestic garden use.	None. Good practice but not a legal requirement.
Registered	More than 10 kilolitres per property on any given day. Use within general authorisations.	Most municipal production boreholes and farm boreholes will need to be registered.	Abstraction on the last day of each month. Water levels and chemistry. Good practice but not a legal requirement.
Licensed	Use exceeds general authorisations.	High-yielding production boreholes.	Abstraction on the last day of each month. Monitoring as per license conditions would typically include chemistry and water levels.

2. Steps for Establishing a Groundwater Management System

STEP 1: Obtain the support and buy in of the WSA

Meet with the technical management of the WSA and provide an outline of the scope of the project, the expected time frames as well as the roles of DWAF, the municipality and others involved in the project. The successful implementation of a groundwater management system, and its sustainability, depends heavily on support from the WSA. Obtain the WSAs support and information about their priority groundwater management sites at the outset of the project.

STEP 2: Identify boreholes that are registered and those that require registration

i. Before commencing, define the physical scope of the project

Will it cover all of the areas under the WSA or is it specific to certain areas only?
It is recommended that a comprehensive plan to cover the entire WSA, be developed.
This should be implemented in phases based on the identified priority areas.

ii. Review available information and reports, including:

- Municipal information
- Municipal GIS
- Water Services Development Plans (WSDPs)
- Water sector plans
- Project completion reports
- Reports on water services provision status
- DWAF information
- Groundwater Information Project (GRIP)
- National Groundwater Database (NGDB)
- DWAF water services information system and GIS
- Other regional databases

iii. Produce a comprehensive list of the production boreholes in the area

This should include small stand-alone abstraction points like handpumps and windpumps, as they will contribute to the overall abstraction within an area. However, the abstraction from these stand-alone boreholes is usually insignificant in comparison to a motorized production borehole, and for the purposes of this exercise, it is most important to capture the major abstraction points. Non-equipped boreholes, handpumps and windmills are useful monitoring sites when a large area or aquifer needs to be assessed.

A significant number of private (Schedule 1) boreholes could collectively account for a significant portion of groundwater use. If Schedule 1 groundwater use is of a scale that warrants priority monitoring, the WSA would have to enact bylaws to compel users to report on groundwater use.

iv. Define the property unit

Is the property unit the district, the local municipal area, the ward or the village boundaries?

Allocate all the production boreholes to their property unit and produce a list of boreholes for the area, following the example in **Table 2**. While producing a list of production boreholes is a once off exercise in the establishment of the groundwater management system, the list needs to be updated and reviewed annually to ensure that it remains current.

Table 2: Example of list of production boreholes

Village name	Population	Borehole number	X Coordinate	Y Coordinate	Property unit	Property size (ha)	Quaternary catchment no.	General authorisation limits (kL/ha/a)	WARMS number	Registered (yes/no)	Licensed (yes/no)

STEP 3: Identify priority monitoring sites from the WSA, CMA, DWAF and other organisations

i. WSAs priority

WSAs are largely concerned with supplying water. Therefore, in relation to groundwater management, they may prioritise monitoring boreholes with the following criteria in mind:

- Villages that are totally dependent on groundwater.
- Villages with large populations.
- A history of scheme failure.
- The cost of emergency supplies should the borehole fail.
- The frequency of water borne diseases in the village.

Obtain a list of priority boreholes from both the technical and the health sections of the WSA.

For a technical assessment, meet with technical staff and establish:

- The boreholes that are considered to yield less water than before (this may be an infrastructure, and in particular, a pump problem).
- The boreholes that give regular “problems”, such as: pumps burning out, air being pumped, clogging (i.e. the borehole or pumps being clogged with slime, bacteria, iron precipitates, mud, etc.), caving-in (e.g. sand is pumped or is suspected to collapse into the borehole, or there is mud or sediment at the bottom of the borehole).

For a health assessment, meet with the health staff and establish:

- The areas where there are water quality problems.
- The boreholes near animal kraals, dipping tanks, stagnant pools, pit latrines and other potential sources of contamination.

ii. CMAs priority

CMAs need to ensure that the available water resources are managed in a sustainable manner, or that they are managed according to particular management objectives. Their priority monitoring sites may be based on:

- Aquifer yield (particularly aquifers vulnerable to over-pumping).
- Aquifer water quality (particularly aquifers susceptible to water quality deterioration with abstraction).
- Aquifers vulnerable to contamination.
- The location of other “types” of monitoring systems (e.g. the CMA may want the WSA to monitor sites closest to where the CMA is doing monitoring for their own needs).
- The monitoring requirements in the license agreement.

Meet with the CMA and establish what they think the WSAs priority monitoring sites should be.

iii. DWAFs priority

DWAF is responsible for overall WRM, and it is most likely that DWAF will have the same monitoring criteria as the CMA.

Meet with DWAFs Regional or Cluster Offices to establish what they believe are the WSAs priority monitoring sites.

iv. Identify other priority monitoring sites from consultants, non-governmental and other organisations

There may be other boreholes that are not on the WSA, CMA or DWAF lists (e.g. newly installed boreholes), or boreholes where hydrogeologists, engineers, social workers or community members have a good reason to believe that they should be monitored. Contact people who have worked or lived in the area, and establish their priority monitoring sites.

Develop a list of priority monitoring sites from the people and organisations above.

STEP 4: Prioritise monitoring sites from the above list

Criteria for prioritising monitoring sites for WSAs should be guided by:

- The need to prevent pump failure (i.e. those sites where it is suspected that water levels are regularly drawn down to the pump intake. Note that surging flow from the discharge pipe indicates this).
- The need to ensure that the aquifer is not being over-pumped and that it will be dependable during droughts.
- The need to get an early warning if the aquifer is contaminated, or if the water quality is deteriorating.
- The cost of emergency supplies, should the borehole fail.

STEP 5: Define the monitoring objectives for each borehole

Define the monitoring objectives for each borehole and how you will know if the purpose for monitoring has been successful. For example:

Table 3: Example of monitoring objectives per borehole

Village	Borehole number	Monitoring purpose	Monitoring needs	Possible action required	Key performance indicators
Xaxa	T23126	To avoid pumping water levels from reaching the pump. To ensure long-term sustainability.	Water levels and flow rates. Water levels and monthly abstraction.	Reduce abstraction rate (litres/second). Reduce abstraction rate (m^3/month).	Pumping water levels are not excessive and the abstraction rate is appropriate for the borehole. Rest water levels are not showing a declining trend over the long-term.
Malini	G56724	To prevent the aquifer from becoming saline.	Electrical conductivity.	Reduce abstraction rate (m^3/month).	Electrical conductivity does not show an increasing trend over the long-term.
Malong	78217	To establish the maximum sustainable abstraction rate.	Water levels, flow rates, monthly abstraction rates, electrical conductivity	Increase abstraction rate (litres/second and / or (m^3/month).	Borehole is not under-pumped. It is pumped at its appropriate rate (litres / second), and for the maximum number of hours per month without negatively affecting the long-term yield or quality of the aquifer, or any negative environmental effects.

STEP 6: Identify and inform role-players

Identify who is currently involved in water services operations and groundwater management. Also identify if there are any groundwater management initiatives taking place within the municipality. Typically, the role-players in water services delivery would include the:

- Municipal Manager.
- Technical Director.
- Deputy Director for water and sanitation.
- Infrastructure Committee of Council.
- Water Services Providers.
- Support Services Agents.
- Consultants to the District Municipality.

STEP 7: Develop the project plan and budget

The project plan should contain:

- The information collected in steps 1 to 5.
- A programme for implementation.
- A project budget, including mentoring and evaluation.

STEP 8: Define job descriptions

The job descriptions included in this section are generic for the typical staffing configuration of a municipality. Individual posts are not identified, since the jobs described need to be accommodated within the water service provision arrangements of municipalities. These different arrangements are described in the ***Framework for groundwater management of community water supply*** (Toolkit for Water Services, Number 1.1), and would include the WSA being the WSP, other municipal WSPs, community-based WSPs (with or without SSAs in place), and external organisations contracted to be the WSP.

The water service provision arrangements of a particular municipality would be detailed in the Section 78 study documentation of the WSA. It is not proposed that new positions are created, but rather that the job descriptions of staff tasked with water services O&M should include these additional groundwater management tasks. The different staff functions required for the groundwater management system are:

- Pump operator.
- Pump operator supervisor.
- Data capture clerk.
- Technical manager.
- Health manager.

i. Pump operator

The pump operator would be responsible for:

- Measuring water levels and abstraction.
- Maintaining a borehole logbook and recording the water levels, abstraction and other significant information in the logbook.
- Ensuring that the borehole monitoring equipment is kept clean, stored in a secure place and is not misused by unauthorised people.
- Implementing changes on how the pump is operated, based on recommendations made by the technical manager and communicated via the pump operator supervisor.

Further information on the responsibilities of the pump operator is available in ***Groundwater monitoring for pump operators*** (Toolkit for Water Services, Number 6.1).

ii. Pump operator supervisor

The pump operator supervisor would be responsible for:

- Support to the pump operator in monitoring activities.
- Regular assessment of the pump operator's performance.
- On the job follow-up training for the pump operator, as required.
- Collection of data from the pump operator, and transferring this data to the data processor located within the technical management office.

iii. Data capture clerk

The data capture clerk would typically be responsible for:

- Entering the monitoring data from the log sheets into a computer database, such as the ***AquiMon GIS Management System*** (Toolkit for Water Services, Number 5.2).
- Maintaining a filing system for completed log sheets.
- Printing out reports and ensuring that the reports are supplied to the technical manager.

iv. Technical manager

The technical manager would be responsible for:

- Overall responsibility for maintaining the groundwater management system, including ensuring that all role-players fulfil their responsibilities.
- Reviewing groundwater management reports.
- Consulting with groundwater specialists, where required.
- Reporting to Council.
- Making changes to the operation of the borehole. This includes instructing the pump operator supervisor to implement changes, and checking to ensure that the changes have taken place.
- Liaising with the health manager on water quality sampling and testing.
- Using monitoring information in the planning of new infrastructure development.

v. Health manager

The health manager would be responsible for:

- Ensuring regular sampling and testing for potability.
- Providing water quality data to the data capture clerk.
- Reporting to council.
- Liaising with the technical manager on projects with water quality problems, and co-ordinating remedial action and new infrastructure planning.

Identify the individuals who will be responsible for each of the job descriptions and ensure that there are individuals available for the two key functions, namely: overall management of the groundwater management system and data capture.

STEP 9: Secure funding

The long-term funding for groundwater management within a municipality should be part of the O&M budget, which would normally be funded through municipal rates and the equitable share allocation.

Project costs to establish a groundwater management system, and the cost for the CMA / DWAF regional staff to undertake the tasks outlined in this document, would require an allocation within the CMA / DWAF budget.

STEP 10: Implement the priority sites

i. Installation of borehole monitoring equipment

Design a system for ensuring that new projects implemented are "monitoring friendly". This includes ensuring that boreholes are properly equipped for monitoring and that the operator has the training, equipment and support required for monitoring to take place. This should be done as part of project implementation, as the cost is insignificant in relation to the project implementation cost. See ***Appendix 1*** for specifications for borehole monitoring equipment.

◎ **Piezometer tubes**

The major cost associated with the installation of piezometer tubes is the removal and reinstallation of the pump and below-ground pipes. A cost-effective method is to get a municipal O&M policy put in place to ensure that whenever a pump is pulled out of a borehole for routine maintenance or repair, a piezometer tube is installed. This would automatically prioritise the equipping of many of the municipal priority boreholes, as the boreholes most under stress are more likely to have breakdowns.

◎ **Water meters**

Most production borehole installations do have a water meter on the rising main. Install water meters where there are none. Again, having a policy of installing meters whenever a borehole is being worked on, can reduce the cost of water meter installation. Water meters need to be checked regularly and maintained. This needs to be included in the O&M schedule of the project.

◎ **Sample taps**

Most production boreholes have a scour near the pump or a sample tap. However, if none exists, these should be installed as per the specifications in ***Appendix 1***.

ii. Capacity Building

Pump operators must be guided in the tasks required for groundwater monitoring and must be supplied with the following equipment:

- Dip meter.
- Logbook.
- Meter rule or tape measure.

While once off training of pump operators provides the basis for developing the skills needed for groundwater monitoring, it is usually not sufficient, and follow up support and supervision is necessary for the operators to become proficient in the tasks of groundwater monitoring.

A useful guideline document for pump operators entitled, ***Groundwater Monitoring for Pump Operators***, is included in the Toolkit for Water Services, Number 6.1.

Pump operator supervisors should be involved in the training of pump operators, as they will provide them with ongoing monitoring, supervision and support. The pump operator supervisor also needs to have a good understanding of the entire groundwater management cycle and their role as the main interface between the on-the-ground activities and the data processing and management functions. In addition to understanding the pump operator's tasks, the pump operator supervisor needs orientation in the following:

- Sampling for EC and pH.
- Evaluating the pump operator's performance.
- Transferring data sheets.

The data capture clerk needs to thoroughly understand the data management system. If a dedicated software package like ***AquiMon*** (Toolkit for Water Services, Number 5.2) is to be used, then the data capture clerk needs to be trained in operating the software.

iii. Establish communication channels and data flow

Develop a flow chart of who provides whom with what information at what intervals, and ensure that all the role-players understand their functions within the system. The communication channels would include the following data flow and reporting:

- Data from the pump operator to the pump operator supervisor.
- Data from the pump operator supervisor to the data capture clerk.
- Data reports from the data capture clerk to technical management.
- Field reports from the pump operator supervisor to technical management.
- Recommendations from technical management to the pump operator supervisor and the pump operator.
- Feedback reports to the pump operator on borehole data.
- Reports from the municipality to the CMA on water use.
- Reports by technical management to Council or water service operations.

iv. Establish a data management system

The data management system will consist of a physical filing system and an electronic data system.

The data capture clerk needs to maintain a physical file with the log sheets for each borehole filed. This must include a cover sheet indicating what data has been received for each borehole, as well as recording what data has been captured electronically. Physical copies of the reports generated by the electronic management system, water quality sample analyses and field reports must also be stored in the physical filing system.

The electronic data management system would either be a spreadsheet or dedicated groundwater management software, such as ***AquiMon*** (Toolkit for Water Services, Number 5.2).

STEP 11: Provide mentorship

Provide ongoing support to the municipality on the operation of the groundwater management system at the management level, and at the pump operator level. Specific areas that will require mentoring include:

- Interpreting monitoring data and making management recommendations based on the hydrogeological assessment of the data.
- Maintaining the flow of information from the pump operator level to management and back.
- Processing the data and maintaining a data management system.
- Collecting and recording data at the pump operator level.

STEP 12: Evaluate and make recommendations

Make regular assessments of the management system and make recommendations for improving the system.

For a sample pump operator evaluation form, see the document entitled ***Groundwater Monitoring for Pump Operators*** (Toolkit for Water Services, Number 6.1).

3. A Quick Approach to Establishing Appropriate Pumping Rates

The best way to establish appropriate pumping rates is to monitor groundwater levels, abstraction and water quality over several years. This, however, is not always necessary and a good indication of the sustainable yield of a borehole and its optimal pumping rate can be obtained after a short period of intensive monitoring. This requires using a data logger (preferably electronic) to monitor the borehole over a period of at least one month of normal pumping.

The steps required are:

- Ensure that the borehole is equipped with a piezometer tube and water meter.
- Install the data logger.
- Analyse the data.
- Modify the pumping schedule.

Appendix 1

Specifications for Borehole Monitoring Equipment

Introduction

It is far more economical to install monitoring equipment (and establish monitoring systems) as a part of project implementation, rather than to retrofit the boreholes at a later stage.

The major cost associated with the installation of monitoring equipment is the removal and replacement of the pump and below-ground pipes, to install a piezometer tube. A cost-effective method is to get an O&M policy put in place to ensure that whenever a pump is pulled out of a borehole for routine maintenance or repair, monitoring equipment is installed.

◎ **Water meter: for measuring abstraction**

- A water meter installed at the borehole is the most effective way of measuring abstraction.
- The water meter must be positioned before any scours or sampling points on the pumping main.
- It must be positioned so that it is easy and safe to read, and must be well clear of any belts or moving parts.
- The meter must be sized to suit the maximum flow from the borehole (it is not correct to specify a meter that is the same size as the pumping main). The valve manufacturers have specifications for minimum and maximum flows for meters, and normally a meter would need to be of a smaller diameter than the pumping main.
- To eliminate the effects of turbulence, a water meter must be preceded (in flow direction) by a length of pipe of the same diameter as the meter, and also followed (in flow direction) by a length of pipe of the same diameter as the meter. The lengths of pipe required before and after the meter, are specified by the meter manufacturer.
- Meters can easily be blocked if the water flowing through them contains sand or other large particles. Generally groundwater is clear of particulate matter. However, badly constructed boreholes in sandy or poorly consolidated aquifers will pump a mixture of water and sand, which can block water meters. Installing an in-line strainer will protect the water meter from blockage.
- Water meters and in line strainers require regular checking and maintenance. This needs to be part of the O&M schedule of the project.

◎ **Sample tap: for water quality sampling**

- A sample tap must be supplied close to the borehole (but after the water meter) for taking samples to monitor water quality.
- The sample tap must be positioned so that it is easy and safe to take samples, and must be well clear of any belts or moving parts.

- Ensure that all taps and fittings are rated for the maximum design pressure at the borehole head.
- Many boreholes have a scour a short distance from the borehole, that can also be used for taking water samples (and for pumping to waste on start-up).

◎ Piezometer tube: for water level monitoring

- A piezometer of 25 millimetres or 32 millimetres diameter must be installed in the borehole to allow for measuring water levels.
- If one wants to install a data logger in the borehole, the piezometer tube must be able to accommodate the diameter of the data logger. For a DIVER data logger, an internal diameter larger than 22 millimetres is required – a minimum of 25 millimetres for LDPe and 32 millimetres for HDPe.
- Getting a dip meter or data logger stuck in a piezometer tube is a costly problem that can be prevented, and all the following points are aimed at avoiding that.
- It is best if the piezometer tube is attached to the outside of the borehole rising main pipes with **broad** clamps or zip ties, but one must take care that the pipe is not constrained by the clamps or zip ties.
- For the same reason, a pipe of more rigid material is better than one of soft material. HDPe is better than LDPe, and if one uses LDPe then class 6 should be used.
- The piezometer tube must have no joins, restrictions, bends or twists in it.
- The bottom of the piezometer must be closed so that the monitoring equipment cannot fall out of the bottom. Slits must be cut in the bottom one metre of pipe, to allow water to enter the tube.
- The top of the piezometer tube must be positioned so that it is secure, and so that readings can be taken safely and easily. The top end must be well clear of any belts or moving parts and must be secure and tamper proof.
- After the pump and piezometer tube have been installed, the piezometer tube must be tested for openness, i.e. insert a dipmeter probe to the bottom of the tube. If it is not open for the full length, the pump and piezometer tube must be re-installed, until it is correct.

◎ Dip meter: for manual water level measurements

- Numerous types of dip meters are available in South Africa, ranging from expensive imported models, to cheaper locally manufactured models, to the homemade “twin flex and voltmeter” models.
- The following specification is recommended:
- Coax cable mounted on a strong cable reel. The length would depend on the requirements for the borehole but would normally be 50 metres or 100 metres. Coax cable is stronger than “twin flex” and it can be easily marked at one metre intervals with a permanent marker.
- The probe should be made of metal that is a good electrical conductor, and be of the smallest possible diameter (to easily fit in the piezometer tube). The probe should have an insulating spacer to stop the meter giving false readings when the probe touches the metal casing of a borehole (if inserted in a non-equipped borehole without a piezometer tube).

- A microvolt meter permanently connected to a 9 volt battery gives good battery life and does not need an on / off switch. The current only flows when the probe is in water, as opposed to an ohmmeter that permanently draws current from the battery. A gauge also uses less current than a light or buzzer.
- The dip meter should be marked at one-metre intervals, and be issued together with a steel metre rule or tape measure, for measuring to centimetre accuracy.

◎ **Logbook**

- Logbooks should have numbered, duplicate, carbonised pages with the original having tear-off serrations.
- A stiff cardboard flap out sheet can be used to put behind the current sheet, to avoid pressing through to the following pages.
- They should also be supplied in a strong plastic zip seal type bag so they can be stored in the pump house, and be protected from water and dirt.
- The logbooks should have a hard cardboard back.
- A few sheets of log paper at the back of the book can be included, so that the operator can plot water levels.
- The cover must have a label that clearly identifies the village; the borehole name; the operator's name; the pump operator supervisor's name and contact details; the height of the datum above the base plate and any other relevant information about the borehole.

Examples of logbook sheets for manually and automatically operated pumps are overleaf in **Table 4** and **Table 5**.

Table 4: Example of a logbook format for a manually operated pump

Settlement name:				Borehole number:			Operator name:		
Date	Before pumping		Time pumping starts	Pumping water level (m)	Time pumping stops	Flow meter after pumping (kl or m³)	Total hours pumped	Volume pumped (kl or m³)	Comments (include: EC measurements; flow measurements; breakdowns and repairs; servicing (e.g. oil changes); water sampling, etc)
	Flow meter after pumping (kl or m³) *F1*	Water level below datum (m)	*T1*		*T2*	*F2*	*(T2-T1)*	*(F2-F1)*	

Table 5: Example of logbook format for an automatically operated pump

Settlement name:				Borehole number:			Operator name:	
Date	**Time of reading**	**Pump on or off**	**TOTALS**					**Comments** (include: EC measurements; flow measurements; breakdowns and repairs; servicing (e.g. oil changes); water sampling, etc)
			Water level below datum (m)	**Water meter reading (kl or m³)**	**Hour meter reading (hrs)**	**Volume pumped (kl or m³)**	**Total hours pumped**	

Glossary and definitions

Aquifer
Defined by the National Water Act (1998) as a geological formation which has structures or textures that hold water or permit appreciable water movement through them.

Ambient groundwater quality
Background water quality. It reflects the groundwater quality of the area at a specific time.

Borehole
Defined by the National Water Act (1998) as a well, excavation or any artificially constructed or improved underground cavity which can be used for the purpose of:

(a) Intercepting, collecting or storing water in or removing water from an aquifer;
(b) Observing and collecting data and information on water in an aquifer; or
(c) Recharging an aquifer.

Catchment Management Agency (CMA)
CMAs are responsible for regional water resource management (National Water Act, 1998).

Determinands
Variables such as ions, pH and temperature to be included in a water quality assessment.

Dip meter
The instrument used to measure the depth to the water level in a borehole.

Groundwater
Water held within a saturated soil, rock-medium, fractures or other cavities within the ground (SANS, 2002).

Groundwater level
The depth to the water level in a borehole or well from the ground.

Groundwater management
Groundwater management for Community Water Supply involves taking responsibility for protecting groundwater from contamination and ensuring its sustainable use.
The main responsibilities are:

(a) Data collection, capture and analysis, and recommendations for operational or behavioural changes based on the data analyses. Operational changes may be, for example, to reduce the abstraction rate. Behavioural changes may include, for example, the restriction of groundwater polluting activities or increasing the monitoring frequency.
(b) Making operational or behavioral changes based on the data analyses.

Groundwater monitoring
Groundwater monitoring forms part of the groundwater management function. Specifically, it includes data collection and capture. Boreholes need to be properly equipped in order to make monitoring possible. A description of all the necessary tools for groundwater monitoring is described in the ***Toolkit for Water Services***.

Groundwater monitoring tools
Tools used in monitoring groundwater, like a water level meter, a flow-meter, a logbook and computer software.

Observation or monitoring borehole

A borehole used to measure changes in groundwater levels (often in response to a nearby pumping borehole), and / or to monitor changes in water quality (either through the collection of water samples or by means of a "down-the-hole" electronic sensor).

Piezometer tube

A tube (manometer), usually a plastic pipe having a diameter of 15 to 25 millimetres, which is inserted into a borehole with the pump, so that groundwater levels can be measured using a dip meter or electronic sensor.

Water board

Defined by the Water Services Act (1997), as "an organ of state established or regarded as having been established in terms of this Act to perform, as its primary activity, a public function"; and the Act further states that the primary activity of a water board is to "provide water services to other water services institutions within its service area".

Water pollution

Defined by the National Water Act (1998) as the direct or indirect alteration of the physical, chemical or biological properties of a water resource so as to make it:

(a) Less fit for any beneficial purpose for which it may reasonably be expected to be used;

or (b) Harmful or potentially harmful:

- i) to the welfare, health or safety of human beings;
- ii) to any aquatic or non-aquatic organisms;
- iii) to the resource quality; or
- iv) to property.

Water services

Defined in the Water Services Act (1997) as covering both water supply and sanitation.

Water Services Authority (WSA)

Municipality responsible for ensuring access to water services (Water Services Act, 1997).

Water services institution

These include Water Services Authorities, Water Services Providers, water boards and water services intermediaries (Water Services Act, 1997).

Water services intermediary

An institution or individual who provides water to consumers but whose primary function is not water services provision. For example, a farmer who provides water to staff as part of a contract of employment, is a water services intermediary (Water Services Act, 1997).

Water Services Provider (WSP)

Any institution that is appointed by a Water Services Authority to provide water services to consumers or to another water services institution (Water Services Act, 1997).

Water table

The surface of a groundwater body at which the water pressure equals atmospheric pressure, i.e. the uppermost level of the groundwater body beneath the land surface.

Water User Association (WUA)

An association of water users, for example, farmers who share a common water resource.